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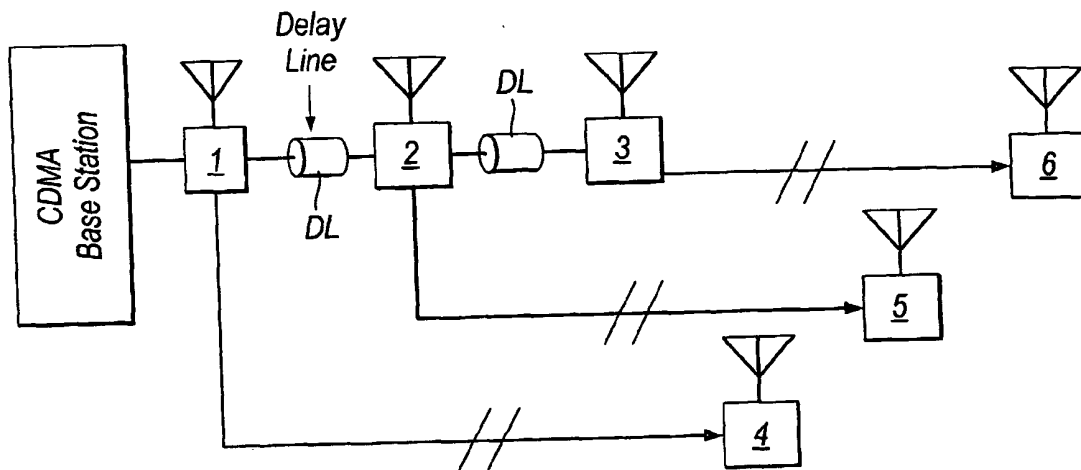
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: A WIRELESS COMMUNICATION SYSTEM AND A METHOD OF OPERATING A WIRELESS COMMUNICATION SYSTEM



(57) Abstract: A wireless communication system includes a distributed antenna arrangement having a plurality of antenna elements arranged in groups and at least one mobile station including a RAKE receiver for combining received signals produced by the antenna elements. The antenna elements producing the strongest antenna signals are assigned to different groups and the antenna signal produced by the different groups of antenna elements are subjected to preset relative delays enabling the antenna signals to be coherently combined.

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A WIRELESS COMMUNICATION SYSTEM AND A METHOD OF OPERATING A WIRELESS COMMUNICATION SYSTEM

This invention relates to a wireless communication system and a method of operating a wireless communication system.

The invention concerns wireless communication systems having distributed antenna arrangements as may be deployed, for example, to provide coverage in an in-building environment, such as an office environment.

In order to enhance the capacity of an in-building distributed antenna arrangement it has been proposed that a time delay element be inserted between adjacent nodes created by individual antenna elements of the distributed antenna arrangement - see, for example, "A CDMA Distributed Antenna System for in-building personal communication service" by H.H. Xia et al, IEEE Journal on Selected Areas in Communications, Vol. 14, No. 4, pp 644-650, May 1996. Such delay reduces self interference or fading when antenna signals produced by different antenna elements are combined in the RAKE receiver of a mobile station. Typically, the delay must be greater than $1/B$, where B is the W-CDMA bandwidth, to enable the RAKE receiver to form a coherent combination of the antenna signals received from individual antenna elements of the distributed antenna arrangement.

Typically, a mobile station includes a RAKE receiver having only a small number of RAKE fingers (typically 3), and this gives rise to a problem when the distributed antenna arrangement has a greater number of antenna elements. In this case, the antenna signals received at the mobile station can create self interference instead of contributing to the desired signal.

With a view to alleviating the problem it is proposed to arrange the antenna elements of a distributed antenna arrangement in groups, with the antenna elements producing the strongest antenna signals at a mobile station being assigned to different groups.

According to one aspect of the invention there is provided a wireless communication system including a mobile station and a base station having a distributed antenna arrangement comprising a plurality of antenna elements for producing antenna signals across an area of coverage of the distributed antenna arrangement, wherein said antenna elements are arranged in groups, antenna elements producing the strongest antenna signals at the mobile station within at least part of said area of coverage are assigned to different said groups and antenna signals produced by the different groups of antenna elements are subjected to preset relative delays enabling the antenna signals to be combined substantially coherently in the mobile station.

In a preferred embodiment, said mobile station includes a RAKE receiver for combining the antenna signals, the RAKE receiver having N RAKE fingers, where N

is an integer equal to the number of said groups.

According to another aspect of the invention there is provided a method of operating a wireless communication system including a mobile station and a base station having a distributed antenna arrangement comprising a plurality of antenna elements for producing antenna signals across an area of coverage of the distributed antenna arrangement, the method including assigning antenna elements producing the strongest antenna signals at the mobile station, within at least part of said area of coverage, to different said groups, and subjecting antenna signals produced by the different groups of antenna elements to preset relative delays enabling the antenna signals to be combined substantially coherently in the mobile station.

An embodiment of the invention is now described, by way of example only, with reference to the sole figure of the drawings which shows a schematic representation of a wireless communication system having a distributed antenna arrangement of which the individual antenna elements are assigned to different groups with a view to reducing self interference of antenna signals received at a mobile station.

In this embodiment, the distributed antenna arrangement has six antenna elements (1-6). The antenna elements are arranged in three groups commensurate with the number of RAKE fingers in the RAKE receiver of a system mobile station (not shown in the drawing). Thus, antenna elements 1,4 form a first group, antenna elements 2,5 form

a second group and antenna elements 3,6 form a third group.

Antenna signals produced by antenna elements of the same group are all subjected to the same preset delay created by an associated delay line represented schematically by the elements DL in the drawing.

In this particular embodiment, the antenna signals produced by antenna elements 3,6 of the third group are subjected to a larger preset delay than the antenna signals produced by antenna elements 2,5 of the second group, and the antenna signals produced by antenna elements 1,4 of the first group are not subjected to any preset delay. In this way, antenna signals produced by the different groups of antenna elements are subjected to preset relative delays, typically greater than $1/B$, where B is the system bandwidth, and can be combined substantially coherently in the mobile station, without significant self interference.

The antenna elements producing the three strongest antenna signals are assigned to different groups. In this particular example, it is assumed that the mobile station is relatively close to antenna elements 1,2,3. Therefore, these antenna elements have the smallest path losses to the mobile station and produce the strongest antenna signals which are combined substantially coherently in the RAKE receiver of the mobile station due to the preset relative delays imposed on the antenna signals produced by the different groups of antenna elements. In view of this, it is likely that the remaining

antenna elements 4,5,6 of the groups will be located further away from the mobile station. These more distant antenna elements produce much weaker signals than the closer antenna elements 1,2,3 and so have no significant adverse impact on the coherence of antenna signals processed by the RAKE receiver in the mobile station.

Alternatively, the mobile station might be closer to antenna elements 4,5,6 which would then produce the strongest antenna signals. In this case, antenna elements 1,2,3 would be more distant, producing weaker antenna signals. Nevertheless, the composition of the three groups and their preset relative delays remain unchanged.

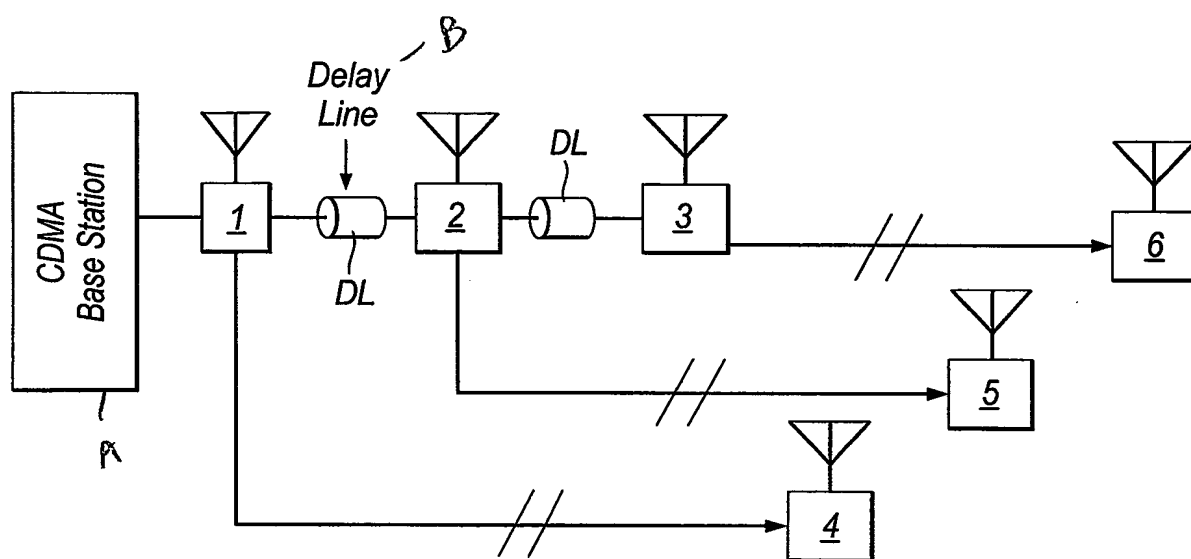
In general, there is a high probability that antenna elements assigned to different groups will produce the strongest antenna signals at all locations across the entire coverage area of the distributed antenna arrangement. However, it will be appreciated that for some distributed antenna arrangements there may be isolated regions within the coverage area for which this is not the case.

CLAIMS

1. A wireless communication system including a mobile station and a base station having a distributed antenna arrangement comprising a plurality of antenna elements for producing antenna signals across an area of coverage of the distributed antenna arrangement, wherein said antenna elements are arranged in groups, antenna elements producing the strongest antenna signals at the mobile station, within at least part of said area of coverage, are assigned to different said groups and antenna signals produced by the different groups of antenna elements are subjected to preset relative delays enabling the antenna signals to be combined substantially coherently in the mobile station.
2. A wireless communication system as claimed in claim 1 wherein said mobile station includes a RAKE receiver having N RAKE fingers, where N is an integer equal to the number of said groups.
3. A wireless communication system as claimed in claim 2 wherein N is 3.
4. A wireless communication system as claimed in any one of claims 1 to 3 wherein antenna signals produced by the antenna elements of one of said groups are not subjected to any preset delay.

5. A wireless communication system as claimed in any one of claims 1 to 4 including at least one delay line, wherein the or each delay line subjects antenna signals produced by all the antenna elements of a respective group to the same preset delay.
6. A method of operating a wireless communication system including a mobile station and a base station having a distributed antenna arrangement comprising a plurality of antenna elements for producing antenna signals across an area of coverage of the distributed antenna arrangement, the method including assigning antenna elements producing the strongest antenna signals at the mobile station, within at least part of said area of coverage, to different said groups, and subjecting antenna signals produced by the different groups of antenna elements to preset relative delays enabling the antenna signals to be combined substantially coherently in the mobile station.
7. A method according to claim 6 wherein the antenna signals produced by the antenna elements of one of the groups are not subjected to any preset delay.
8. A wireless communication system substantially as herein described with reference to the accompanying drawing.
9. A method of operating a wireless communication system substantially as herein

described with reference to the accompanying drawing.



INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 03/03213

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H04B7/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, COMPENDEX, INSPEC, PAJ, IBM-TDB, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 92 10890 A (QUALCOMM INC) 25 June 1992 (1992-06-25) abstract page 1, line 9 - line 13 page 2, line 8 - line 18 page 4, line 6 - line 9 page 5, line 26 -page 6, line 5 page 7, line 20 -page 9, line 9 page 17, line 30 -page 19, line 18 figures 1-5	1-7
X	US 5 513 176 A (GILHOUSEN KLEIN S ET AL) 30 April 1996 (1996-04-30) abstract column 1, line 15 -column 6, line 22 figures 1-11	1-7
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

A document defining the general state of the art which is not considered to be of particular relevance

E earlier document but published on or after the international filing date

L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

O document referring to an oral disclosure, use, exhibition or other means

P document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

G document member of the same patent family

Date of the actual completion of the international search

5 November 2003

Date of mailing of the international search report

26/11/2003

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Schreib, F

INTERNATIONAL SEARCH REPORT

Internati...ication No
PCT/GB 03/03213

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 533 011 A (GILHOUSEN KLEIN S ET AL) 2 July 1996 (1996-07-02) abstract column 1, line 10 -column 6, line 22 figures 1-11 ---	1-7
X	US 5 781 541 A (SCHNEIDER ALLAN) 14 July 1998 (1998-07-14) abstract column 3, line 13 -column 4, line 65 column 7, line 52 - line 55 column 13, line 40 -column 14, line 16 figures 2,4,6 ---	1-7
A	WO 02 19565 A (NOKIA MOBILE PHONES LTD ;KUCHI KIRAN (US)) 7 March 2002 (2002-03-07) abstract page 1 -page 4, line 4 page 8, line 15 - line 19 figures 1A,2,3A,4 -----	1-7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 03/03213

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 8, 9
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this International application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 8,9

The term "substantially as herein described with reference to the accompanying drawing" used in claims 8 and 9 is vague and unclear and leaves the reader in doubt as to the meaning of the technical features to which it refers, thereby rendering the definition of the subject-matter of said claims unclear (Article 6 PCT). Therefore no meaningful search of claim 8 and 9 is possible.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International

Application No

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Information on patent family members

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